Research on Interdisciplinary Architecture based on Technology & History

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Master of Science in Advanced Architectural Design

by

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Abstract

The diversity of architecture constructs the flexible, changeable and unpredictable world. Nowadays technology creates infinite possibility on every field, including fabrication in architecture. The relationship between old and new, tradition and technology in architecture is a source of some confusion, which influenced the method of architecture design as well as the development of architecture industry. Combined with relative research, there are three questions to be figured out -- what role does tradition play in architecture? What role does technology play in architecture? What is the role of architecture?

The author took Florence Cathedral as an example to explain the role of tradition in architecture. Architecture reflects human's memory and refracts accumulation of human society. And history gives architecture the sense of stability and the meaning of the existing, which evokes meaning beyond the physical building.

The author took one of optional studio about criminal behavior as an example to describe the utilization of technology in architecture. Technology not only accelarates the construction process, but also forces architecture to evolve to serve its final proposal.

At last, the author took the design studio about Augmented Reality in Buffalo to claim the relationship between history and technology in architecture. The analysis about designing process comes to the conclusion that the role of architecture is to serve human experience.

Key words: history, technology, architecture, human experience

Bibliography Sketch

Shixuan Sun, male, is born in Wuhan, Hubei Province, China in August 13th, 1994.

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He graduated from Tsinghua University in 2018 for master degree of architecture.

He has studied Master degree of Advanced Architectural Design in Cornell University since 2018.

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The diversity of architecture constructs the flexible, changeable and unpredictable world. The dimension of time and space intersects at one point to form the concrete or wood building. But, nowadays technology creates infinite possibility on every field, including fabrication in architecture. This brings a revolution to architecture, which usually remains conservative. The relationship between old and new, tradition and technology in architecture is a source of some confusion, which influenced my choice to investigate the ecology territory.

There are three main questions that wait to be figured out: what role does tradition play in architecture? What role does technology play in architecture? What is the role of architecture?

As we all know, architecture originates from a single shelter, which can be constructed through wood, concrete or even tree branches. It is history that provides the human dwelling place a sense of art or a sense of living. That is to say, architecture reflects human's memory and refracts accumulation of human society. In my fall semester's class -- Architecture, Space, Structure, -- I took Florence Cathedral as an example to do the research.[1] The first part of the research is to create digital drawings of the building, while the second part of the research is to recreate digital buildings based on the drawings. This circular process provides me an opportunity to explain the cathedral's design from a modern view as well as to translate design method from a historical to the current time. The construction process of Florence Cathedral last from 1286 in Gothic style to 1436 in Renaissance style. Filippo Brunelleschi combined the new-style dome with the original nave together through architecture design. Though born under different background, the dome and the nave reached harmony with control of proportion. Under the analysis of proportion, its facade and section can be divided by certain size regular shape. The complex ornament and complicated space is organized by basic geometry elements. With further analysis on its form, force transmission becomes the core algorithm in the cathedral. No matter how the nave is constructed or the dome, architects could not escape from restriction of gravity. The unify of proportion and structure achieves inheritance between Brunelleschi and Cambio, which also informs my redesign of the building. In this case, there are two layers of tradition requiring evaluation. Whenever the dome was designed or the building is reorganized, tradition is inherited in the development process. At the same time, because human civilization is an accumulation of memory, history gives architecture the sense of stability and the meaning of the existing, which evokes meaning beyond the physical building.

[1] Page 4-6. Resource: the author drew it.

Another pole of architecture is technology. The architecture industry has continuously evolved from the so-called primitive hut. The improvement of technology gives architecture industry new material and new construction methods. The moment can be marked from when people learned to use stone to build rooms, while the replacement of stone to concrete breakthroughs artificial construction's limitation. Nowadays human civilization development has been accelerated after the industrial revolution. Not only industrial production and mechanization status has increased in huge amounts, but also the earth's surface area covered by artificial construction surpasses previous limits. When traditional construction method is continuously optimized, new fabrication methods are gradually utilized in relevant fields. Freeform construction behaves as one kind of technology focus because of its higher material efficiency, faster manufacturing speed, more form possibility and more construction accuracy compared with traditional methods.

In the spring semester, I took Martin Miller's optional studio about ornament discrimination.[2] The studio is separated into three phases. Phase 1 is to utilize Computer Numerical Control(CNC) to draw two dimensional paintings; phase 2 is to invent tiles based on existing ornament; and phase 3 is to design a chapel as well as confession space according to the research. Traditional image or basic ideas can be deconstructed or repeated in order to create new projects based on our understanding of one kind of religion. This design process can be considered as the combination of technology and architecture. Machines or relative technology perform as accurate translator from human idea to real architecture. But we cannot imagine what the final project exactly looks like until the machine finishes fabrication. In the translation process, it is interesting to figure out that mistakes caused by machines rely not on design but human beings. Under this technology environment, human behavior becomes an inaccurate or unpredictable element. Human, technology and architecture construct a triangle network in the design field, which defines the final buildings together. In the previous time, people stayed at dominated stage, using tools to build, while tools were the restrictive element. Now these three aspects form a stable stage in the design process. The utilization of technology forces architecture to evolve to serve its final proposal.

With regard to the role of architecture, it seems hard to define what architecture is or what role architecture performs. To conclude the aforementioned parts, architecture as the bridge between imagination and realistic world, is easily influenced by the aesthetic tendency of

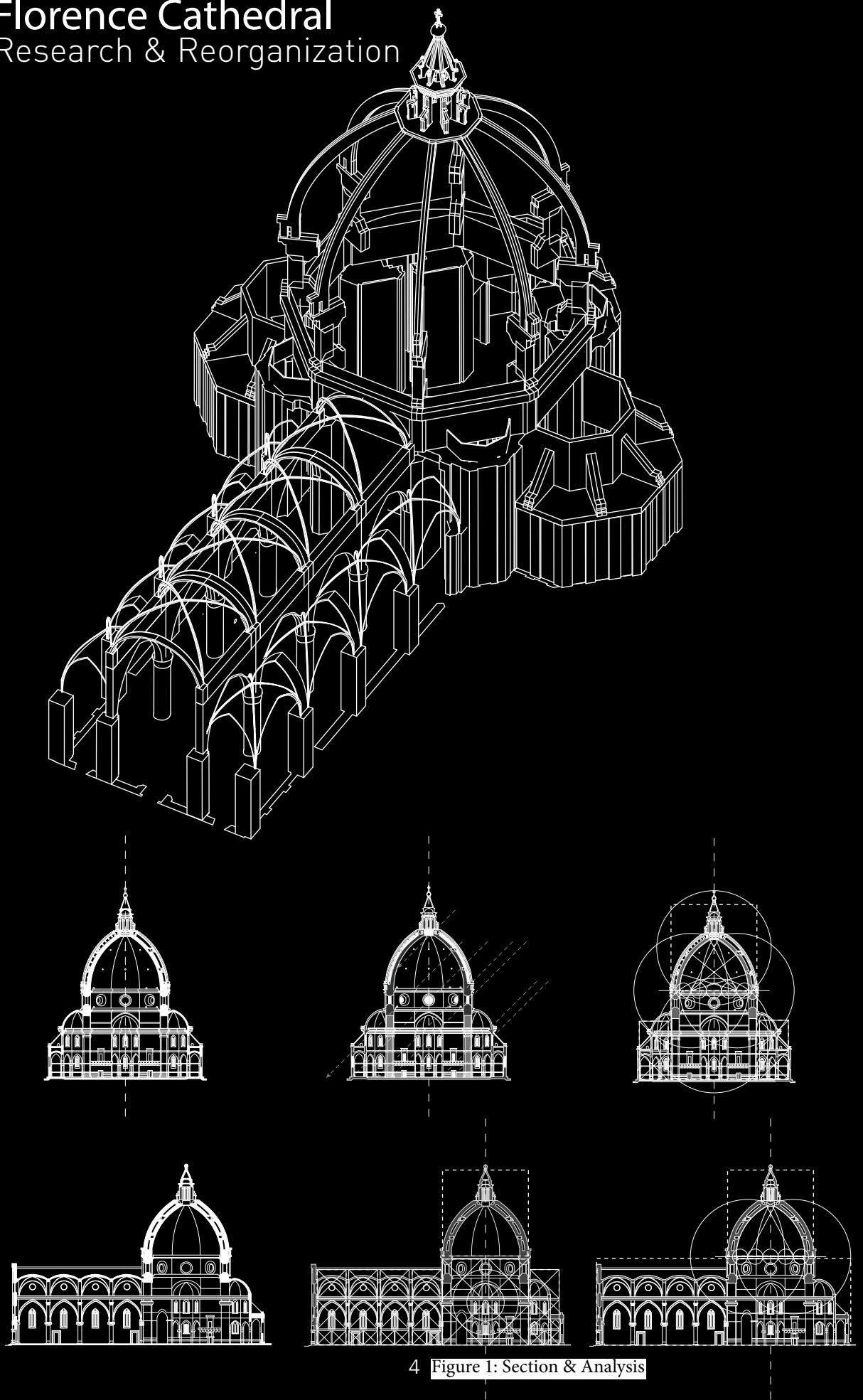
[2] Page 7-10. Resource: the author drew it.

civilization, while architecture is constructed by advanced technology. Tradition and technology act as two poles of architecture in the real world, which both provide reasonable support to decorate architecture. But, it is easy to argue that technology, tradition and architecture cannot establish a fair triangle-shaped relationship. Architecture exists beyond tradition and technology, which amounts to the fact that architecture aims for a goal beyond tradition and technology. In my fall semester, I took John Zissovici's design studio about Augmented Reality(AR).[3] The project chose to utilize advanced technology to build something in the Delaware park in Buffalo. At the beginning point, it is impossible to form any proper connection between AR and real park. The only way to get a breakthrough is to turn to Buffalo city to dig out its texture and public memory. Silo city, which once was mainly functional buildings, now becomes empty constructions, though it contains the memory of the city's booming and decaying history. Hence, I decide to reorganize and review this period of Buffalo city in the park, based on an augmented reality technique. Technology offers the only opportunity to revitalize the memory of history, which shows a potential combination of two poles. But, the question comes to what I would like to achieve on the site, or what goal this project has. After considering all the elements in time and space, human experience comes to the stage. Humans, as the core of modern civilization, compose the society. Augmented reality creates possibility for people to experience different dimensions of time and to gain various memories of Buffalo within the Delaware park. This result explains the fact that architecture can behave as a translator. Architecture can translate knowledge or ideas from other fields to enhance human experience. Therefore, the role of architecture is to serve human experience.

After investigation on the aforementioned three questions, the complex relationship between old and new, tradition and technology in architecture leads to one core idea -- interdisciplinary architecture. With the development of civilization, neither tradition nor technology could rule architecture. Only human experience matters. Architecture provides solutions to daily life through design strategies. From this process, design is a means to improve the lives for all the city's residents and communities. Considering this background, architects can translate innovative ideas from one industry to another to serve the goal. Hence, architects should expand their horizons to interdisciplinary fields to accumulate knowledge to expand the future potential of architecture design.

[3] Page 11-12. Resource: the author drew it.

01 Florence Cathedral
Research & Reorganization



4 Figure 1: Section & Analysis

Figure 2: Plan & Analysis

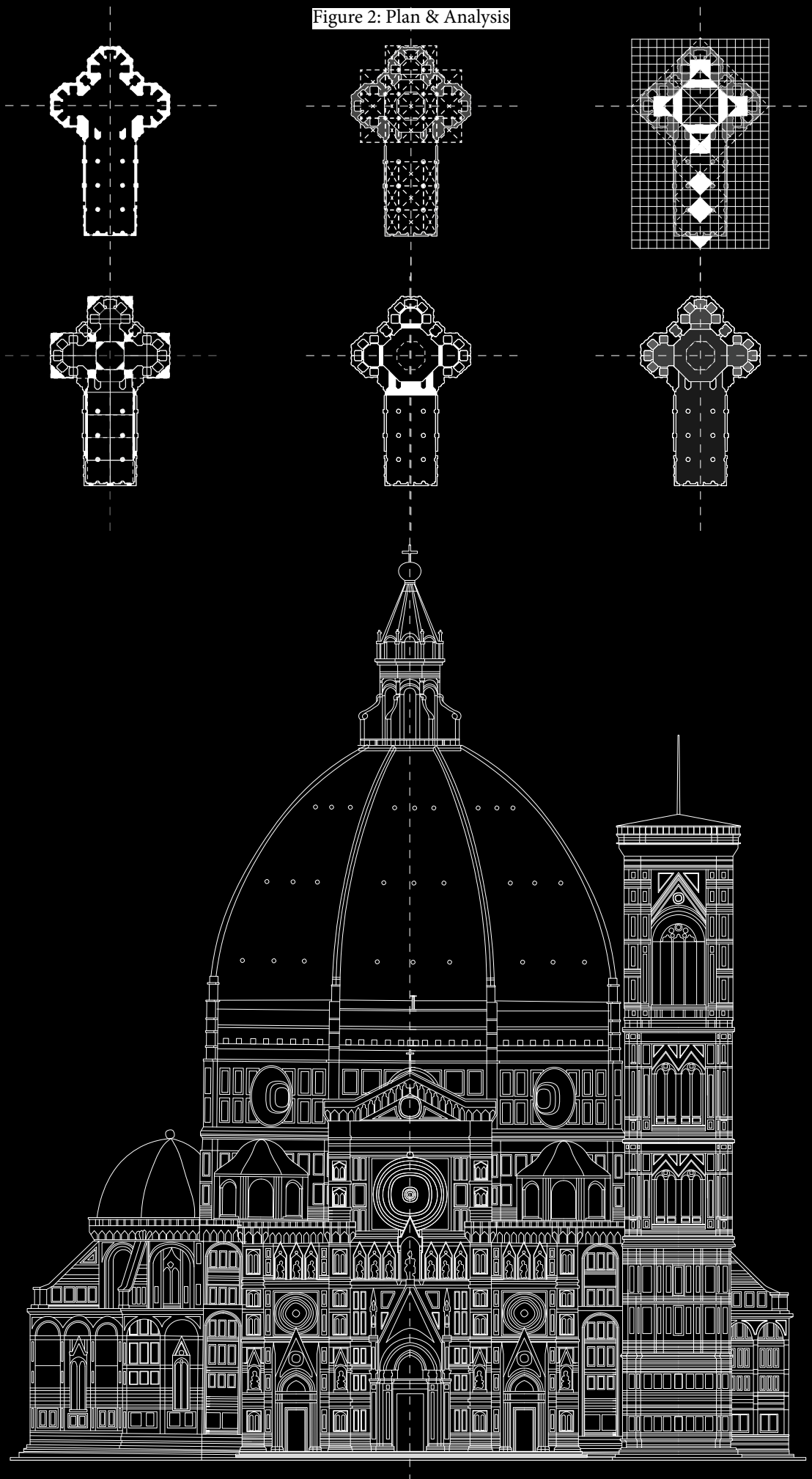
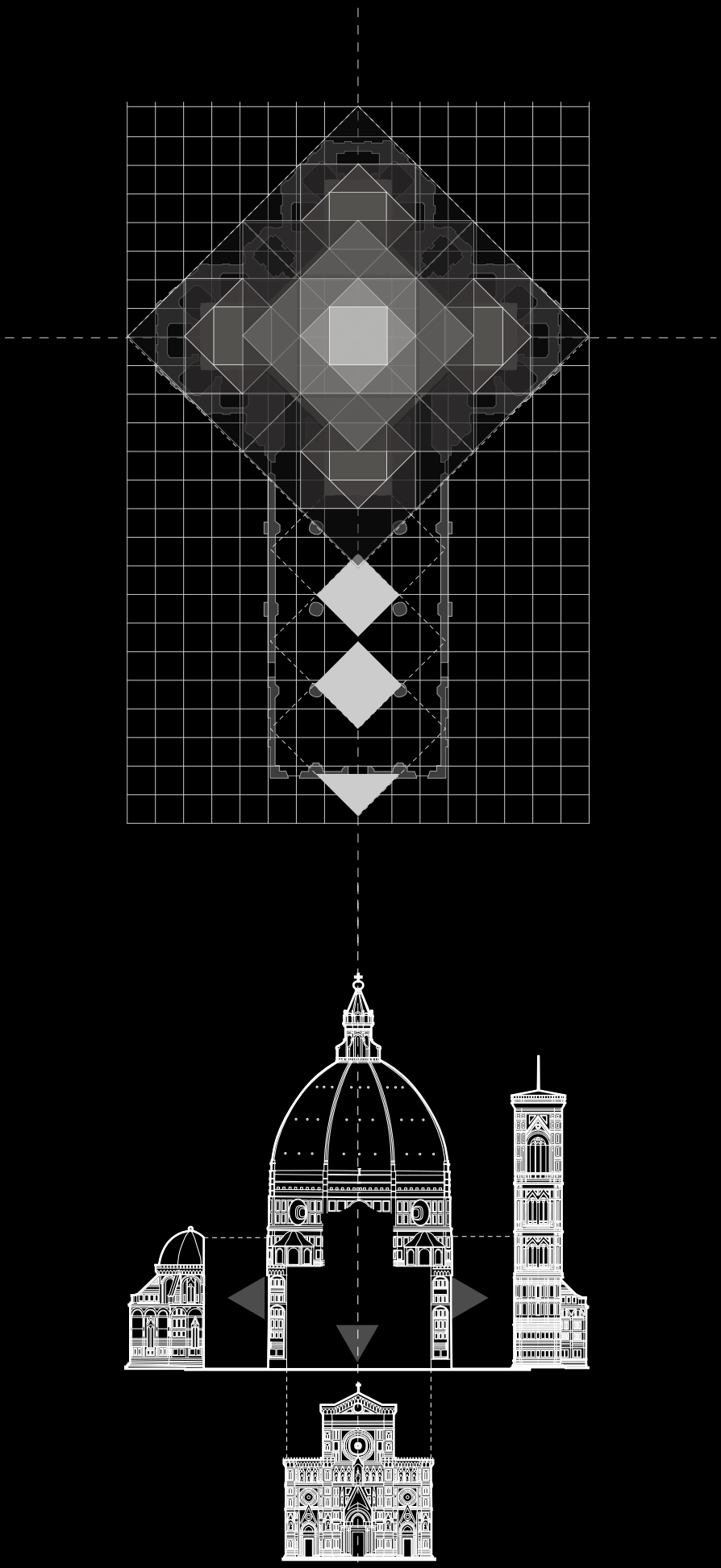


Figure 3: Plan & Analysis



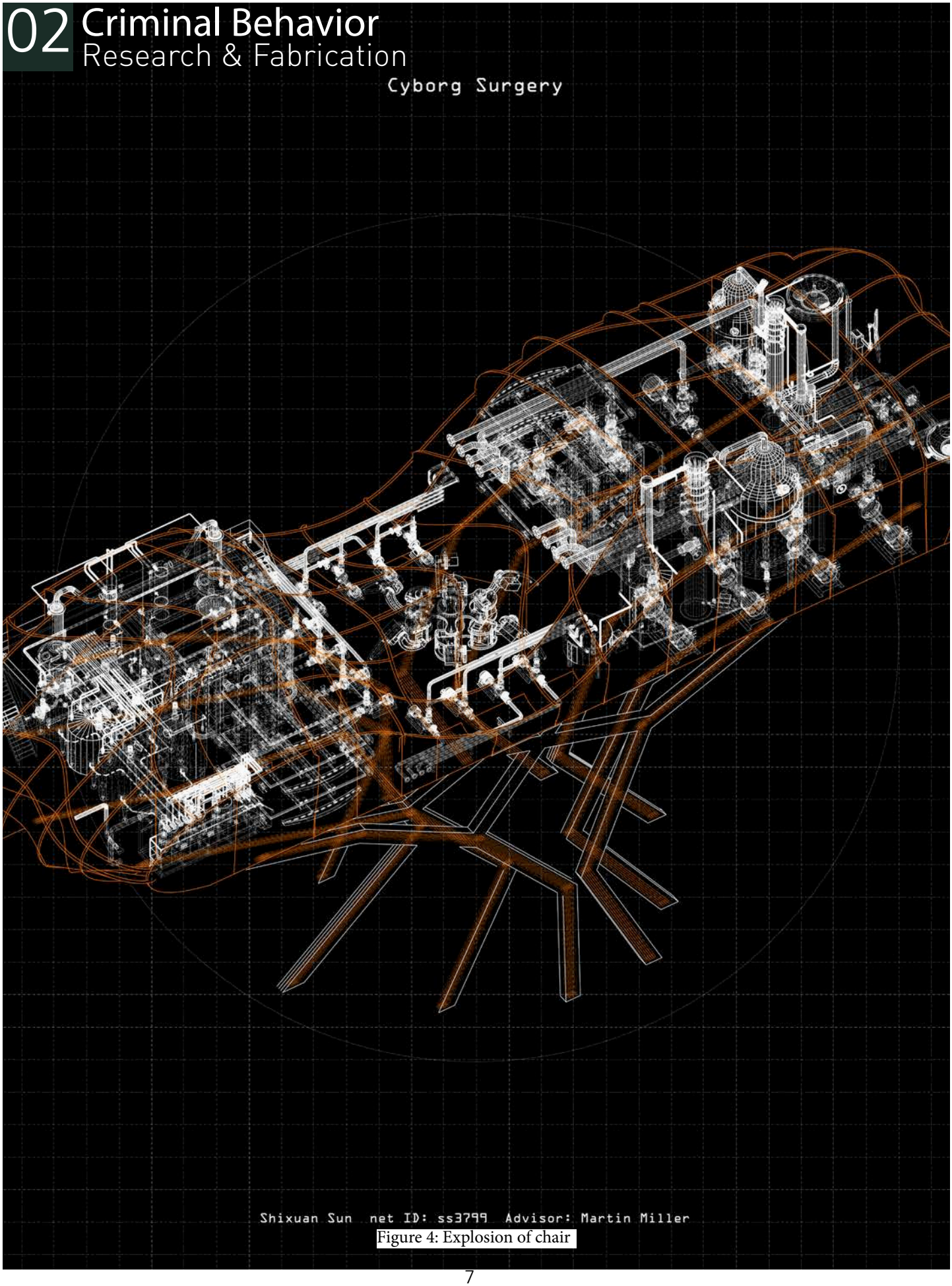


Figure 4: Explosion of chair

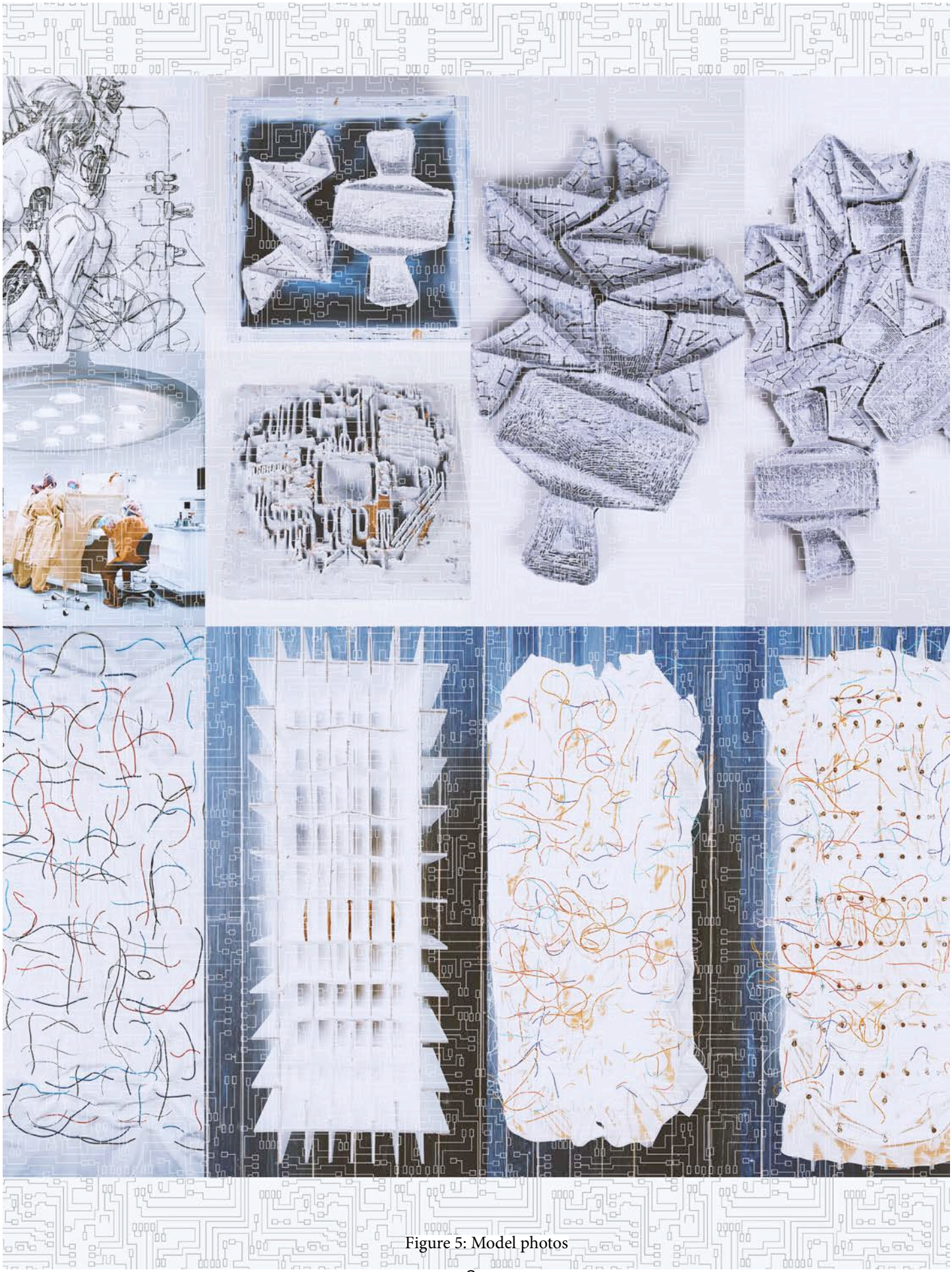


Figure 5: Model photos

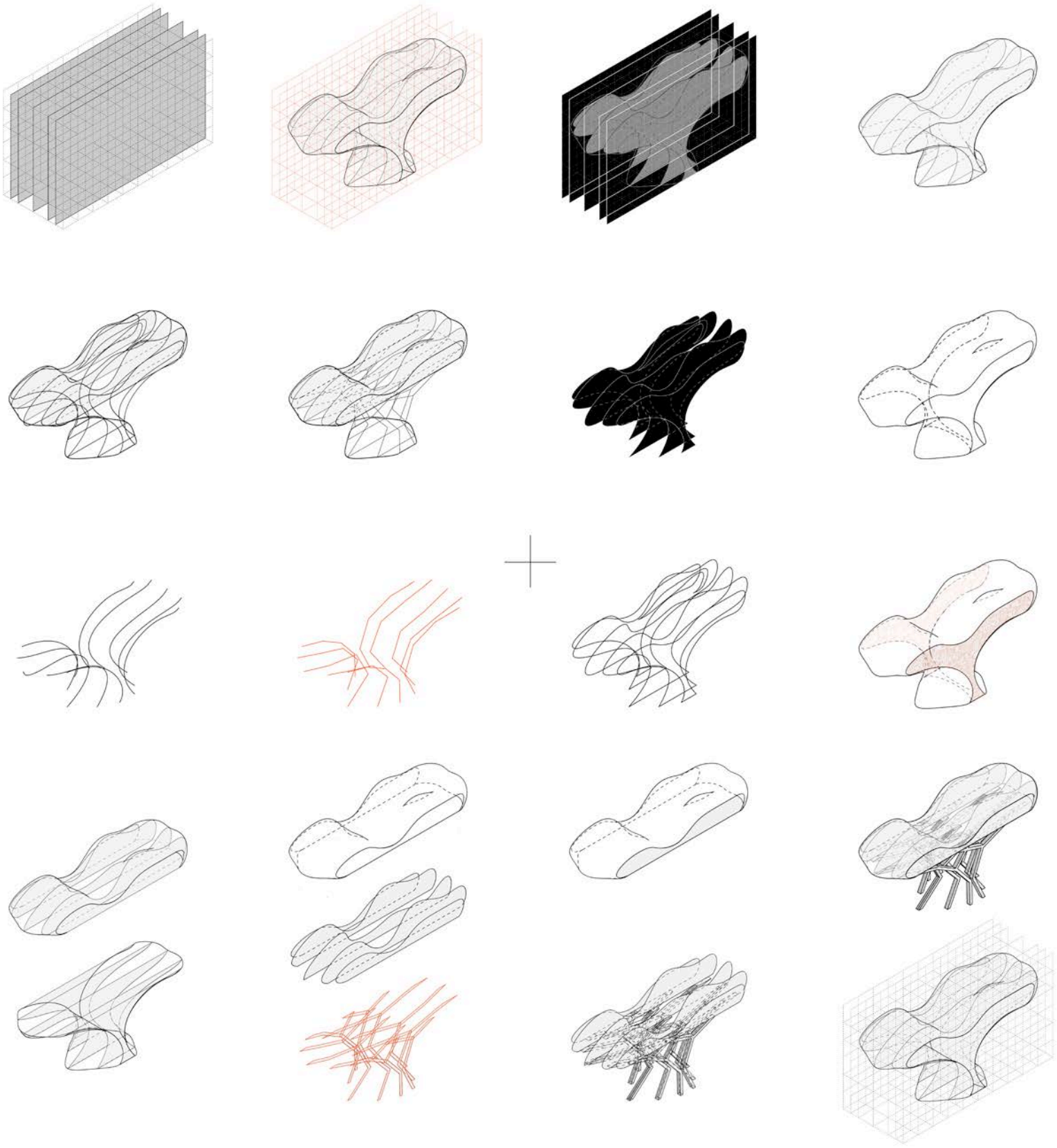


Figure 6: Form & Analysis

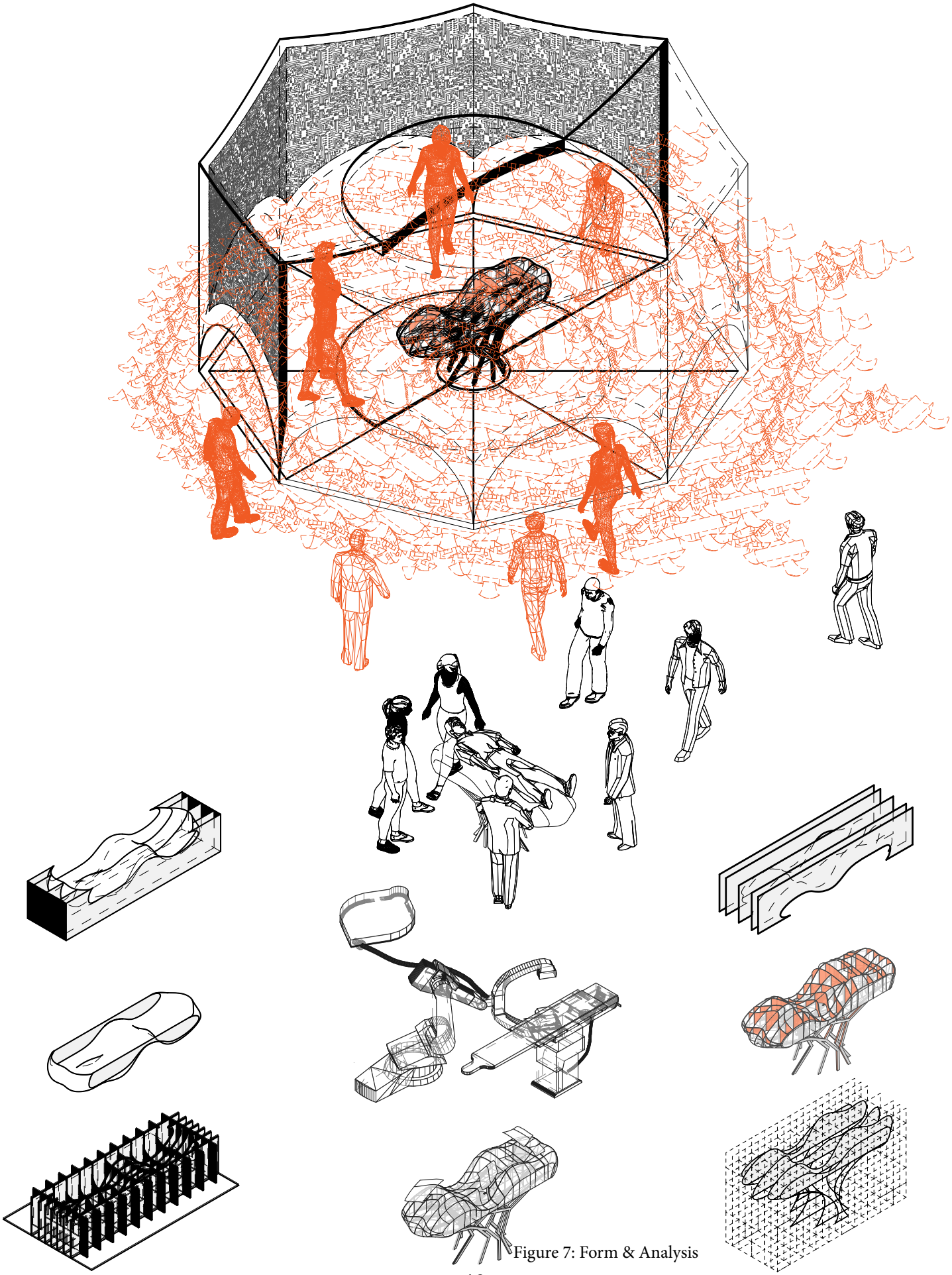


Figure 7: Form & Analysis

Figure 8: Perspective

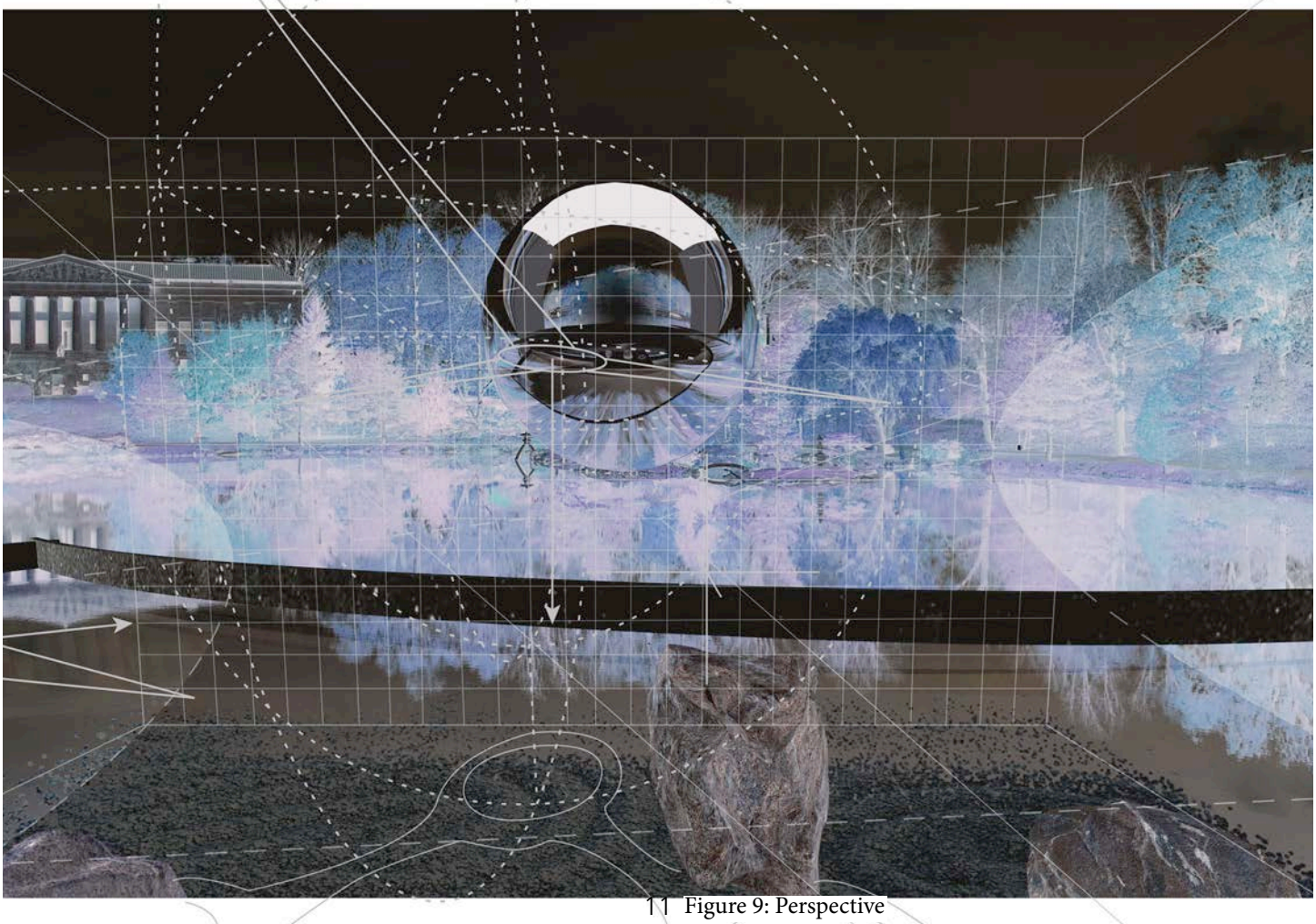


Figure 9: Perspective

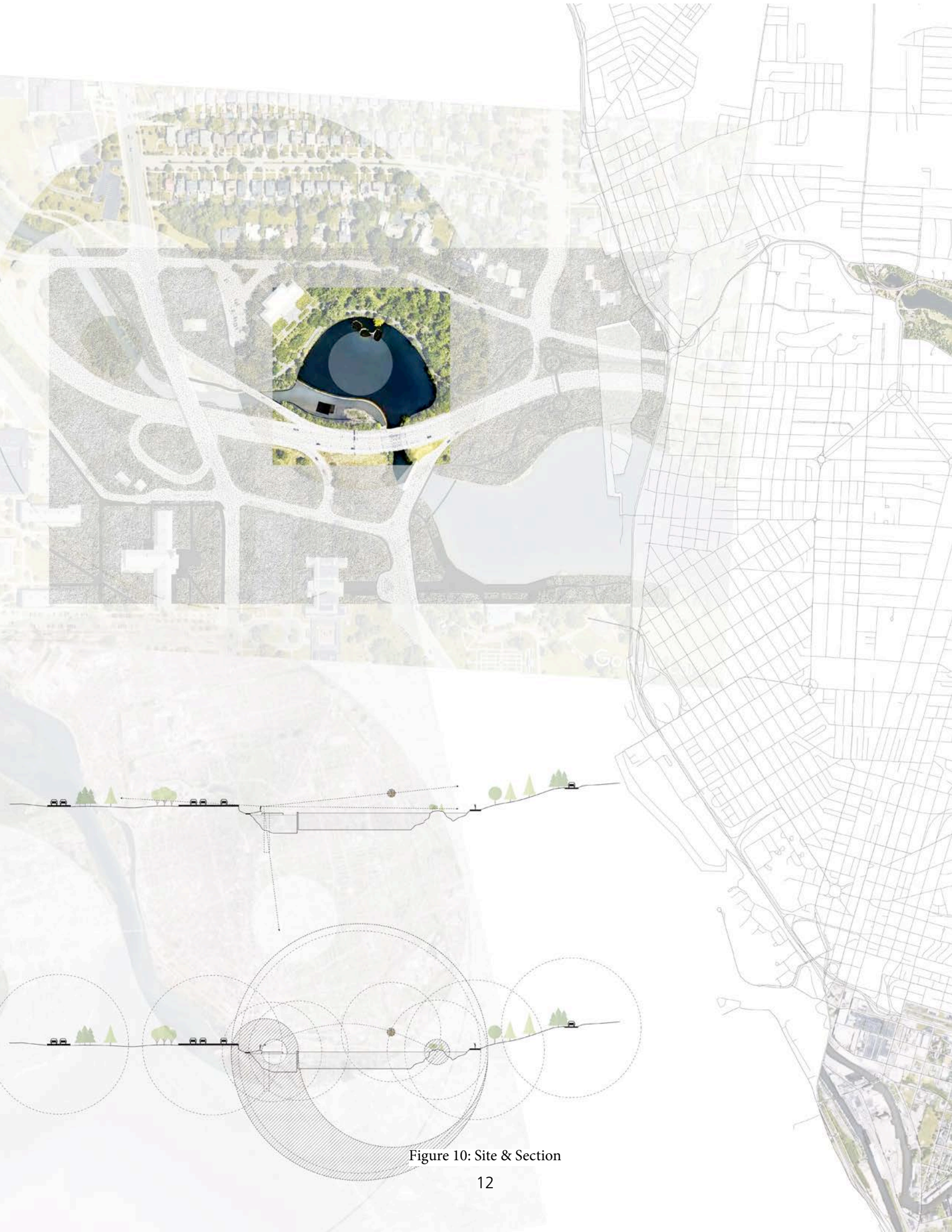


Figure 10: Site & Section

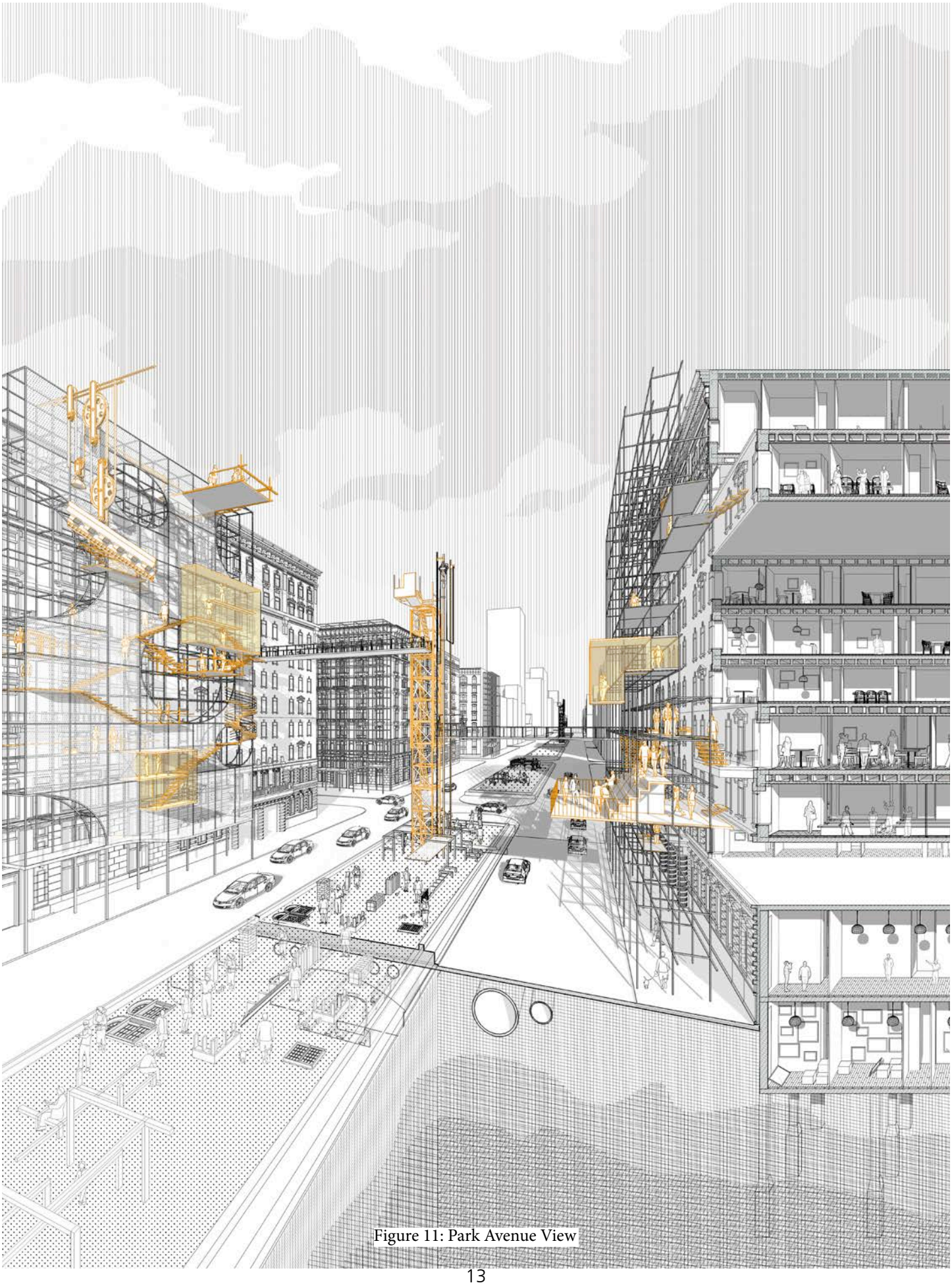


Figure 11: Park Avenue View

04

Scaffolding City

Steel condo & homeless

The project locates in Park Avenue, New Yor
City, from 64th street to 82th street. Throug
former investigation on Zillow, apartments her
had high perception in empty status. Anothe
thing that happens there is that some c
buildings are in construction process because c
Local Law 10 & 11. Hence, scaffoldings construc
part of streetscape on Park Avenue.

Our team decided to reuse empty apartment
for art gallery function as well as living or othe
community functions. Scaffoldings are utilize
as a trigger to connect, revitalize and exten
the existing environment. Neiborghs can reus
them as community center, while visitors ca
visit gallerys by them.

2018 Summer Urban Studio
Adviser: David Eugin Moon, Nahyun Hwang
Collaborator: Maitai Kunawong, Chen Shen, Tang Binhan
Contribution: Concept 30%, Analysis 30%, Design 30%

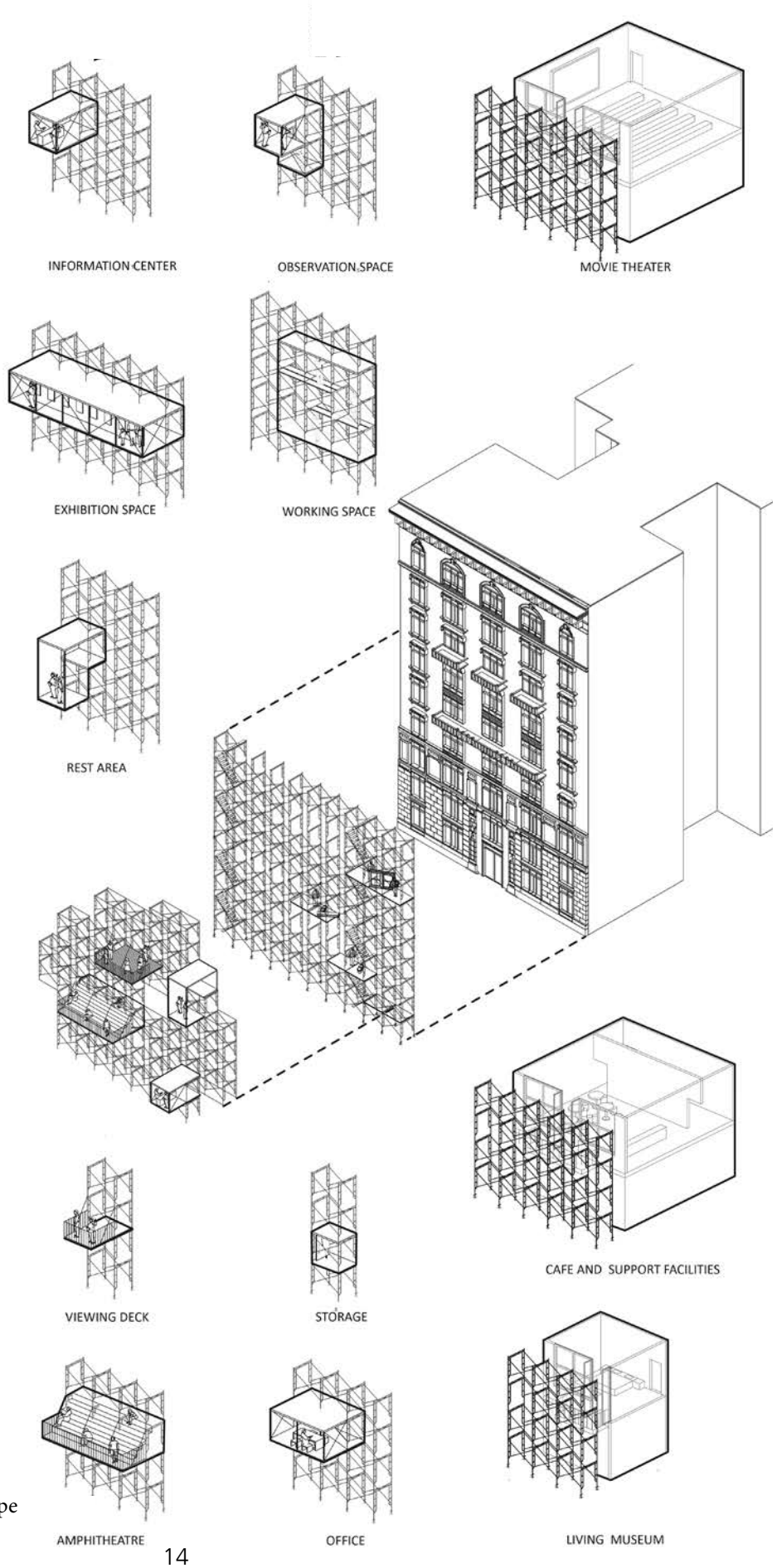


Figure 12: Prototype

05 Waste to Energy

Circulation trash recycle & urban entertainment

Attributed to rapid development of technology and popularised digitalization, cities are experiencing evolution, as well as daily lifestyles. Urban public environment, which provides passing possibilities and activity space for cities, has intense connection with infrastructure. Daily lifestyles, which is composed of a man or a woman's behaviour possibility and family's regular life, has been supported by certain consumption of food, water, electricity, while producing waster everyday.

"Waste To Energy", the process of generating energy in the form of electricity or heat from the primary treatment of waste, offers one way to recover energy from waste. The "waste to energy" system makes connection between urban scale and individual scale, not only ameliorating family's waste reuse efficiency, but also reducing certain environmental pollution in city.

2018 Summer Ecology Studio
Adviser: Tei Carpenter & Jesse LeCavalier
Collaborator: Yang Yang, Maitai Kunawong, Xiaotong Wang, Su Yeon Chi
Contribution: Concept 40%, Analysis 30%, Design 30%, Physical model 50%, Rendering 30%

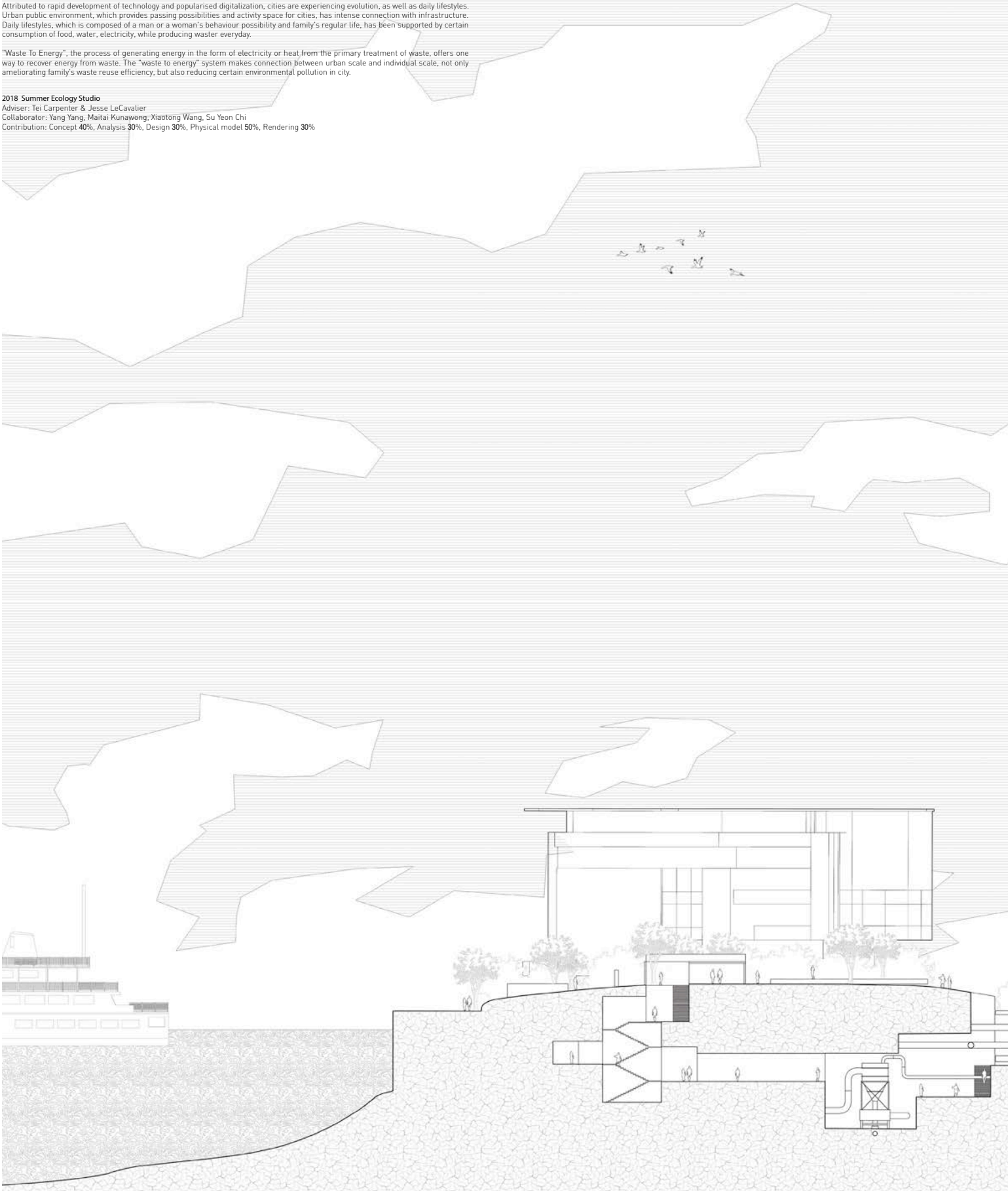
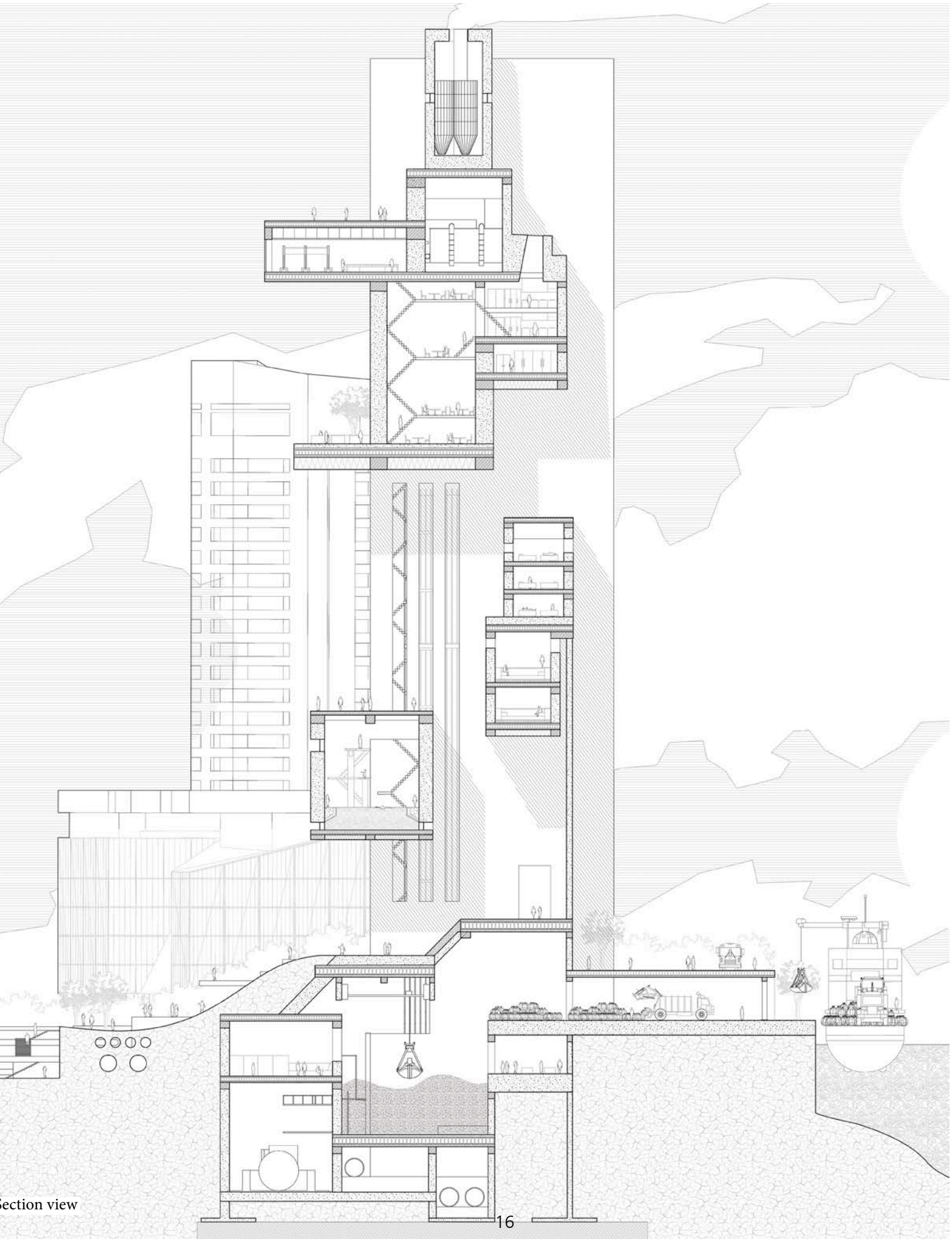


Figure 13: S



Section view

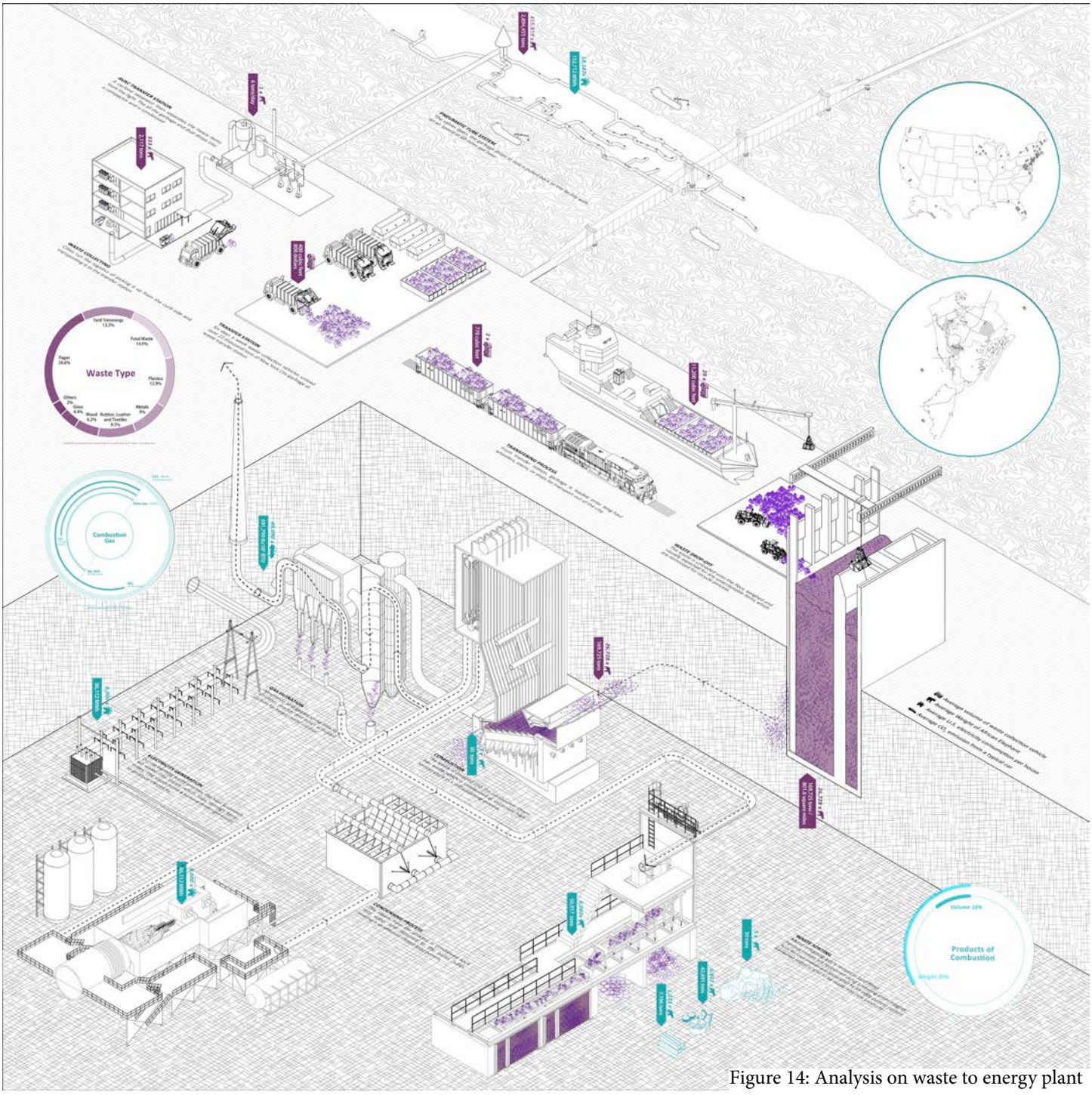


Figure 14: Analysis on waste to energy plant

[Introduction]

The project locates at Roosevelt Island, New York. We analyzed waste transfering process firstly, calculating amount of everyday's garbage in the city. Then we assumed that a waste-to-energy factory would be built on the Roosevelt Island, which would be used for generating electricty for the island from burning garbage. Furthermore, to build one city complex based on "waste to energy" could renovate urban infrastructure of waste disposal and create possibilities of public activity. The factory can be transformed to "vertical city plaza" combined with "waste-to-energy" function.

[Waste Collection]

Pineumatic Tube System The valves open and the garbage drops in and is pulled back to the facility with an air speed of 60 miles per hour.

AVAC transfer station A cyclone separator separates the heavy items from the light. All the garbage and dust drop into a compactor and is condensed.

Waste collection Cities run the logistics of picking it up from the curb-side and transporting it to the transfer station

Transfer station Six days a week waste collection vehicles unload over 22 thousand tons of New York City garbage at waster transfer station

Transfering process From transfer station, garbage is loaded onto long-haul wheelers, trains, or ships for transport out of the city.

Waste drop-off The waste is unloaded onto the floor; weighed and visually aspected for any unacceptable items which are removed for recycle process

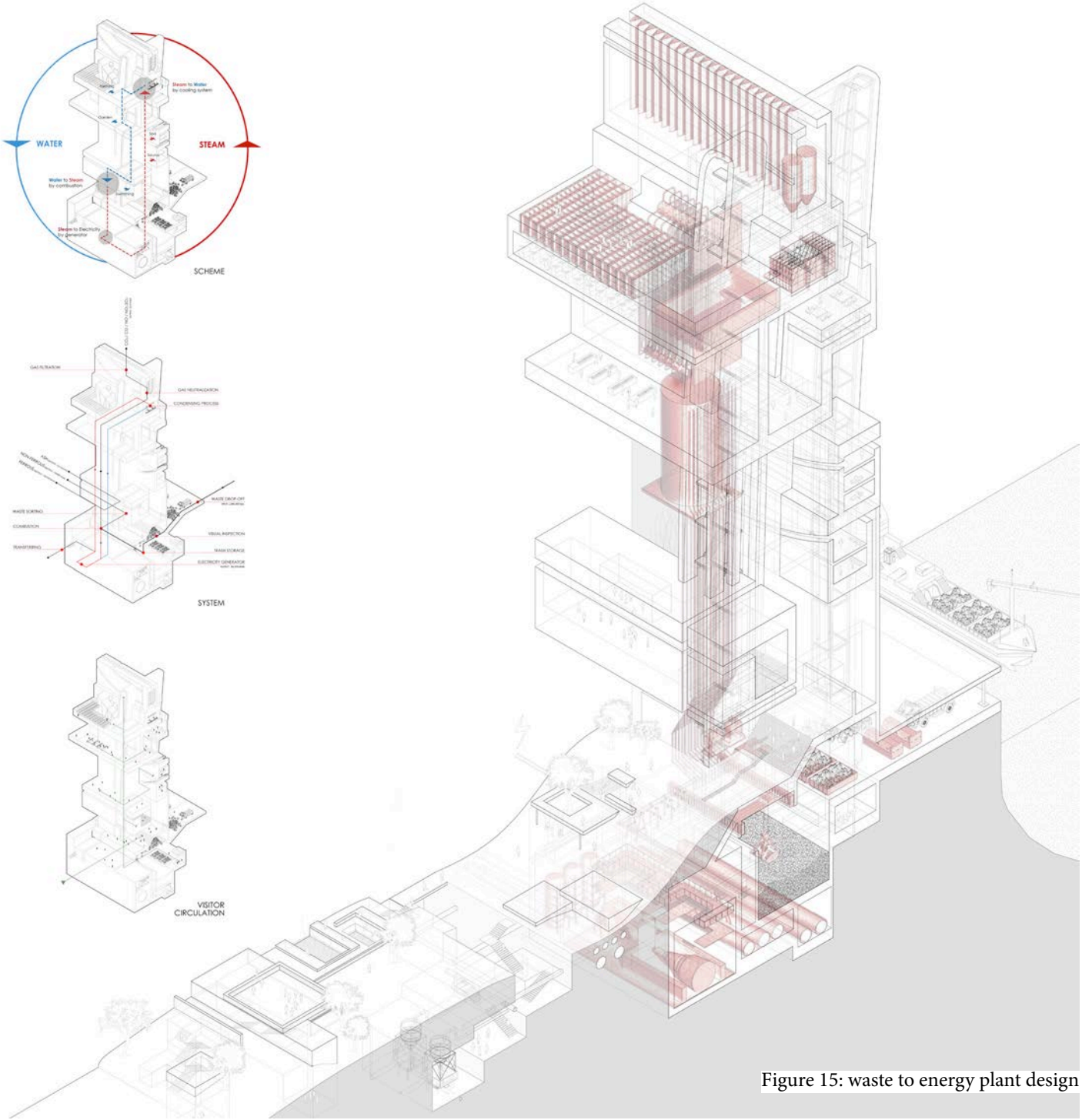


Figure 15: waste to energy plant design

[Waste-to-energy Process]

Waste sorting
Metal remaining ash is reused or land filled. Ferrous metals are recovered using a rotating drum magnet. Non-ferrous metals are separated by an eddy current system. Collected metal is sold to be made onto new products.

Combustion
The waste is dropped into the combustion chamber waste which is combusted at extremely high temperature in a self-sustaining process.

Condensing process
The steam from the process is condensed back into water and returned to the boiler tubes, making it an efficient closed-loop system.

Gas filtration
Neutralize acid gasses using lime in a scrubber reactor and inject activated carbon for heavy-metal control.

Electricity generation
During burning waste process, the heat is converted water into steam which rises through boiler tubes. The steam turns a turbine driven generator to produce electricity.

06 Gateway Urban Design

Pedestrian friendly & Factory renovation & Workforce housing

This project locates in Lakewood, Cleveland, OH, combining land use planning, environmental planning and urban design together. The Lakewood is poised to address the 5-year economic and workforce development plan of Cuyahoga County: an investment opportunity for workforce housing and supporting infrastructure. The Detroit Avenue/West 117th Street focus area is located along the boundary of Lakewood and Cleveland, serving as a "seam" that connects the two municipalities. The intersection of Detroit Ave and West 117th in particular is an important gateway between them. Our design aims at renewing one whole area in order to revitalize regional economy, environment and community.

2018 Autumn Land Use, Environmental Planning, Urban Design Workshop
Adviser: Mitchell Glass
Collaborator: Anna Makido, Eden Marek, Victor Tran
Contribution: Concept 40%, Analysis 30%, Design 30%, Rendering 40%

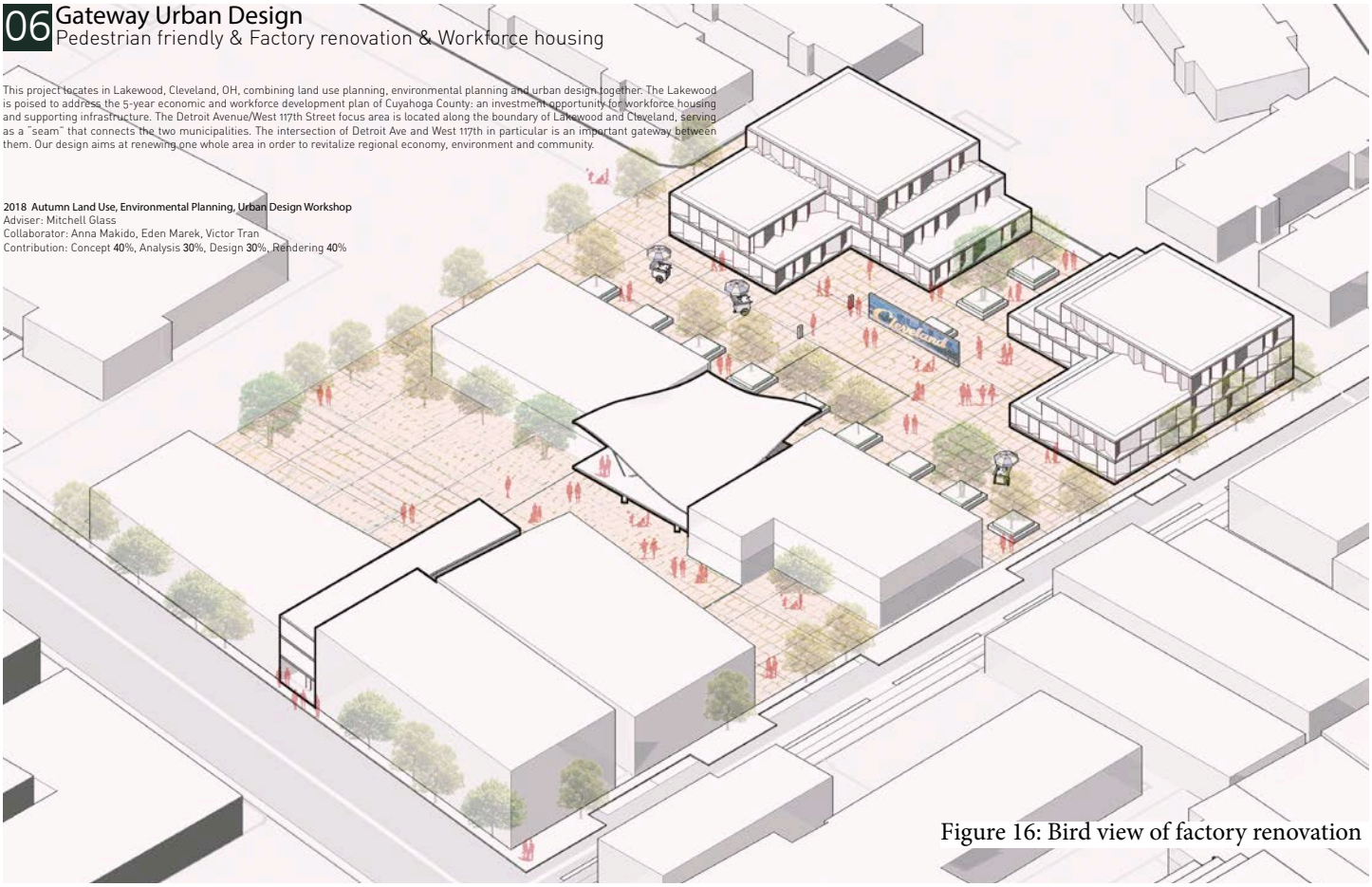


Figure 16: Bird view of factory renovation

Figure 17: Plan of Lakewood

Figure 18: Perpective view of plaza

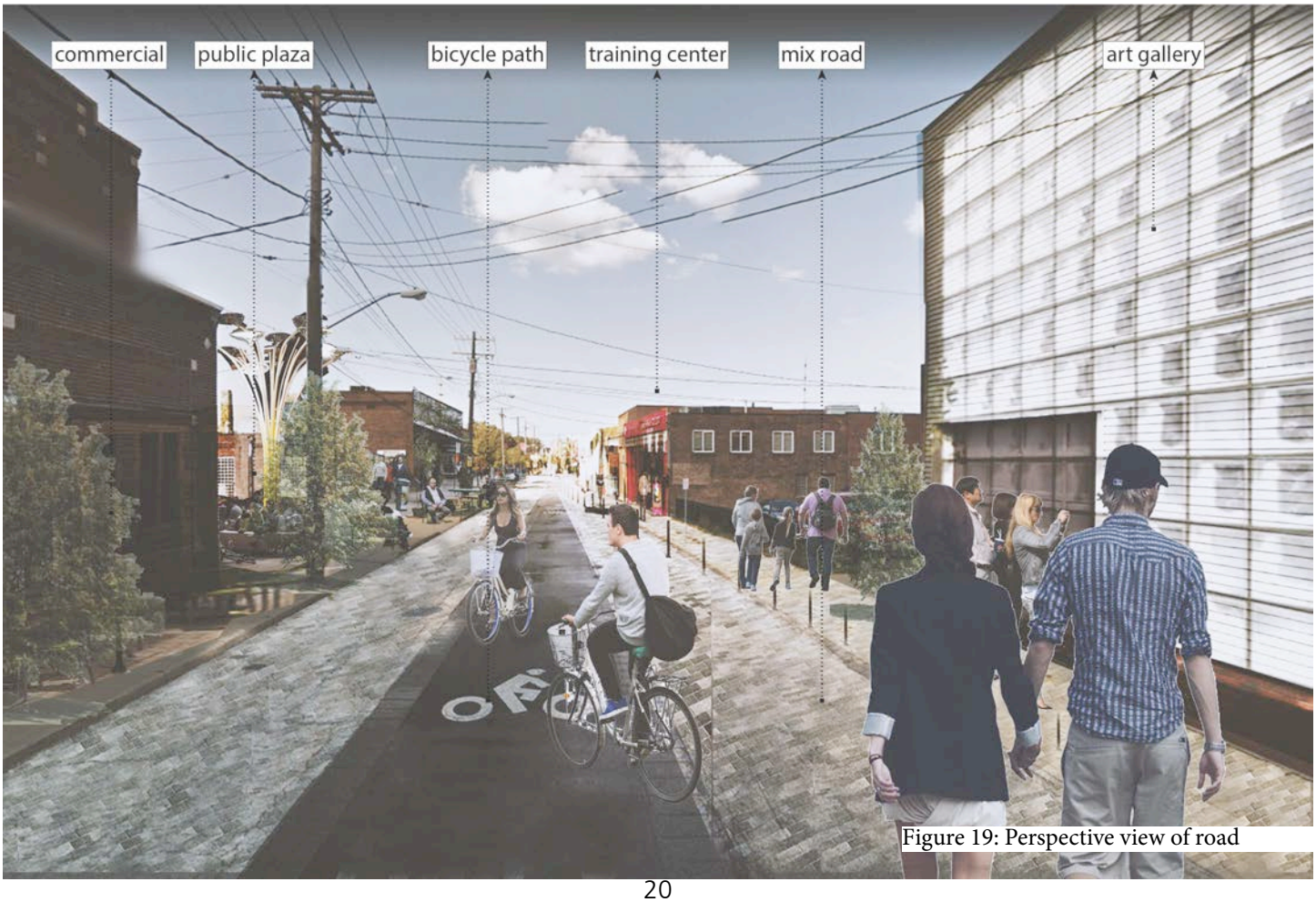


Figure 19: Perspective view of road

Market Analysis

Cornell conducted a thorough market study of on-campus and off-campus housing conditions through surveys, site inspections, and GIS. These results were reported in its Student Housing Master Plan published in October 2016.

As of the date of the report, Cornell has enough capacity to accommodate 6% of the 7,589 graduate and professional population in existing on-campus housing assets. The existing inventory is spread across Hasbrouck, Hughes Hall, Thurston, and 13 South Avenue, and traditional Residence Halls. Without Maplewood, the total capacity is 463 students, and the new on-campus apartments will nearly triple the on-campus supply for graduate students.

94% of graduate students live off-campus at Cornell, and students have reported in stakeholder meetings that the key determinant for selecting where to live is affordability. In general, students also mentioned that they would prefer more on-campus housing dedicated for upperclassmen. This would alleviate the stress that comes with lack of supply, as students feel pressured to seek other options in Collegetown.

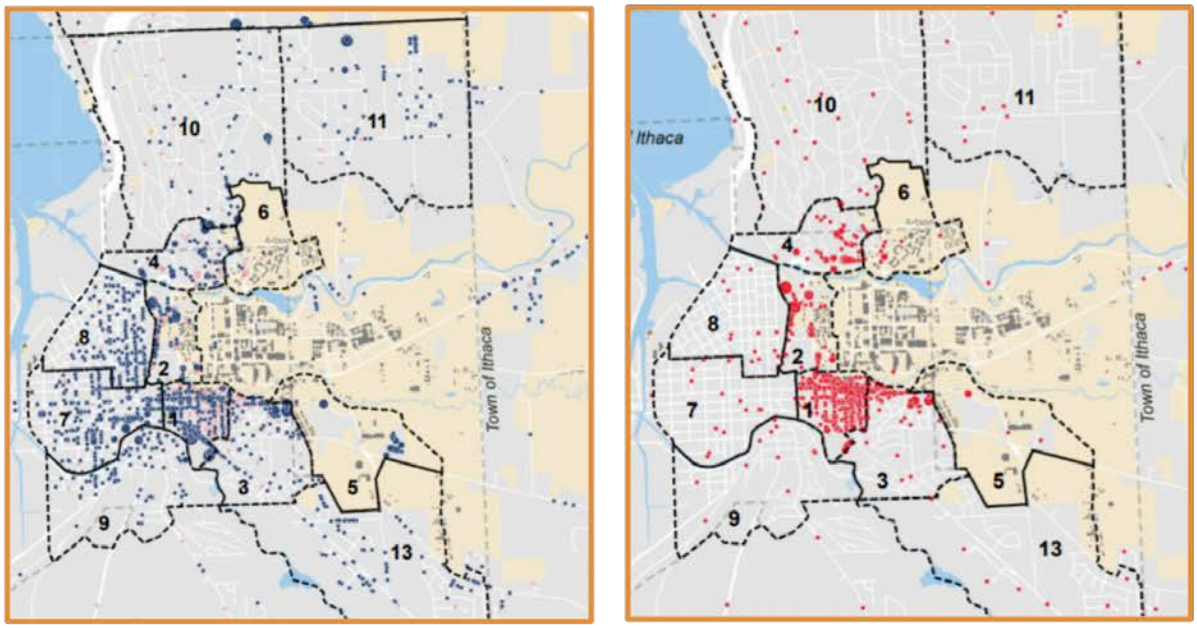


Figure 20 Off-campus living accommodations for graduate and prostudents (left) and undergraduates (right). Undergraduates are more concentrated in the Collegetown areas, while graduate and professional students are dispersed around Ithaca. Source: Cornell Housing Master Plan.

Although 58% of undergraduate students housed in off-campus accommodations live on Collegetown, the geographic distribution of graduate and professional students is more even. Graduate students want tightly knit communities and accommodations in close proximity to campus, but their prioritization of housing affordability pushes most people to distant locations. Commuting times to campus via TCAT bus or private transportation are a secondary but

critical factor for graduate students; about 75% live along a regularly serviced bus route that goes through the Cornell campus.

Even with the availability of public transportation for commuting to campus, 40% of graduate and professional students live more than a 30 minute walk from class. The average walk to campus among all graduate students takes 17 minutes. Using the 2016 distribution of the graduate student population walking time to Central Campus and Maplewood's distance from Cornell, analysis shows that the impact of the new development could decrease the commute of 328 students from over 30 minutes to approximately 20 minutes.

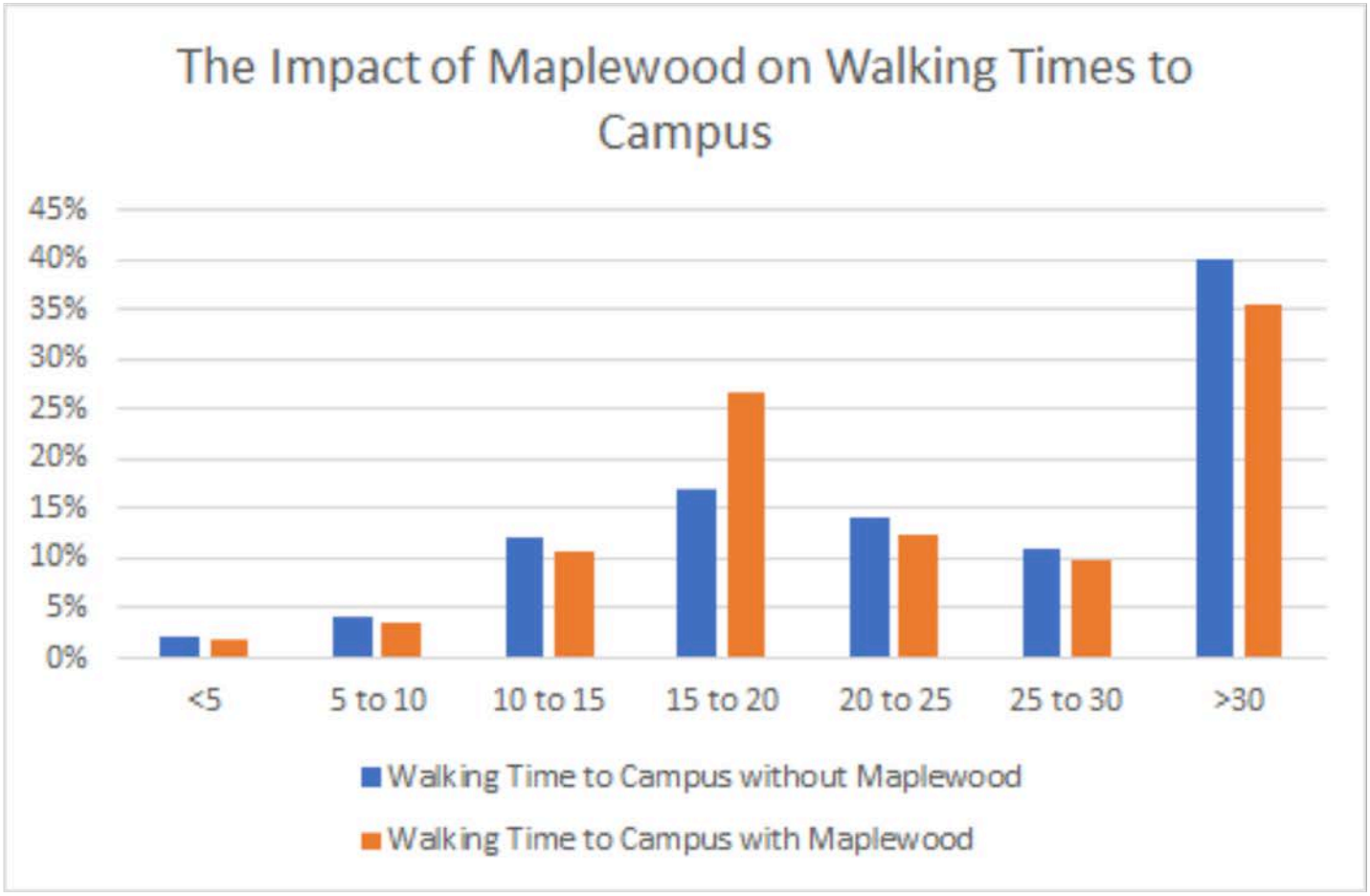


Figure 21 Impact on walking times to campus for graduate and professional students with the addition of new housing supply in Maplewood. The figure uses a total student population of 7,589 in 2016.

Existing rents in the off-campus tend to decrease as distance from campus increases. Belle Sherman has the highest rent for a 1 bedroom apartment at $1,350 per month, while Collegetown has the highest rent for a 2 bedroom apartment at $1,050 per month. Rents in Collegetown have risen at a 2.8% compound annual growth rate since 2000.

The new Maplewood apartments are located at the edge of geographical location 5 as outlined in the Cornell Housing Master Plan. However, it is immediately next to the Belle Sherman

Planning and Entitlement Issues

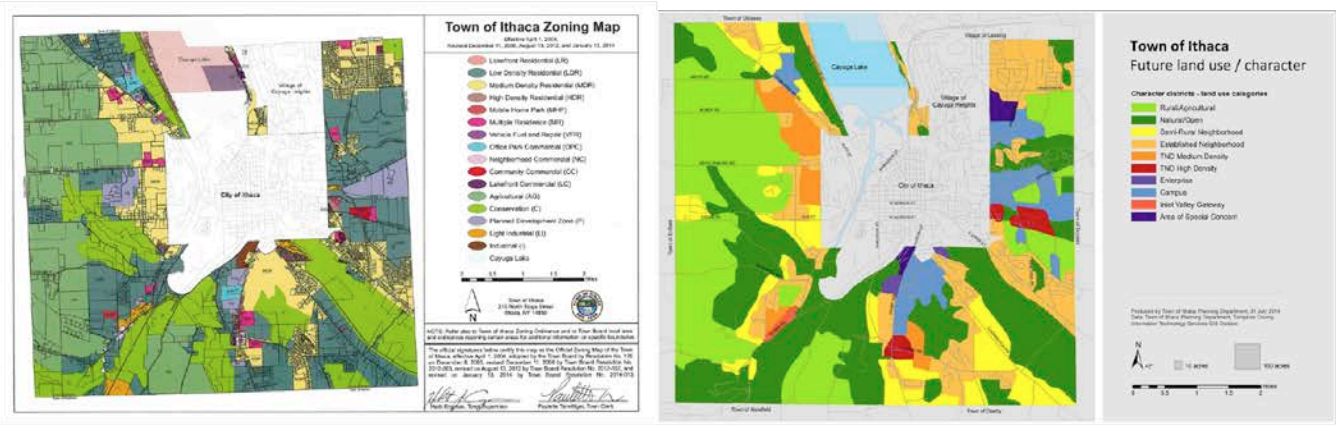


Figure 22. Zoning map (left) and future land use (right) in the Town of Ithaca based on its 2014 Comprehensive Plan. Maplewood falls within the red "TND" High Density area in the future land use map within the East Hill neighborhood, which is adjacent to the Cornell Campus. Source: Town of Ithaca.

Project Entitlements and Zoning

Cornell University owns the land, while EdR owns its improvements to the land. EdR signed a ground lease with the university to develop the site and buildings for a duration of 50 years. According to Chris Balestra, who is a planner with the Town of Ithaca, "99% of the project is in the Town of Ithaca, not the city of Ithaca."[1] This led to an approvals process managed by the town municipality. Maplewood's location between Maple Avenue and Mitchell Street in the Town of Ithaca is one of few areas zoned for a high-density neighborhood. It is surrounded by a large area of low-density residential; other zones nearby include medium density residential, one Light Industrial area, and one Multiple Residence zone. In the future, the town would like for the entire area to be transformed into high density residential. According to Balestra, the Town Board considered the public benefits of the project and agreed to rezone the area to accommodate EdR's request for higher density.

Town Supervisor Bill Goodman added: "That East Hill area is certainly one of the parts identified in our comprehensive plan for greater density, so we can have more walkable, mixed-use neighborhoods."[2] Furthermore, the integrated retail in Maplewood will add to the tax base of the town, which is important since older developments on the land owned by Cornell were tax-exempt.

The project integrates New Urbanist and pedestrian-friendly characteristics, which does not mesh well with the existing unclear and outdated zoning regulations. However, EdR and Cornell were able to work with the Town of Ithaca to designate a Planned Development Zone (PDZ) for the property. This utilizes a DIY methodology through which the development can gain approval using a form-based code.

[1] Balestra (2018).
[2] Reynolds (2016).

Figure 23. Evolution of the Maplewood Redevelopment plan over time, progressing from the old site on the left to a more updated version on the right. The most notable change is the relocation of high-density apartment buildings along Mitchell Street with each iteration. Source: Torti Gallas and Partners.

Project Financing (Sources and Uses, Performance to Proforma)

In September 2018 near the end of construction, EdR was acquired by Greystar in a $4.6 billion cash transaction. This marked Greystar's commitment to the student housing market in its residential portfolio. Although the Greystar acquisition was a significant event, it did not affect EdR's role in the project as the private sector developer and manager. However, it may affect the way EdR provides financing for its projects in the future. Much of the financing for Maplewood was completed before the Greystar acquisition.

Figure 24. The Greystar acquisition of EdR has removed a key financing component of EdR's ONE Plan. Source: Greystar.

EdR has a unique structure for its projects, and it applied its ONE Plan to Maplewood. Under this structure, EdR owns and raised 100% of the equity stake, while 0% of the project's finances come from debt. It accomplished this equity raise through a secondary share offering, which occurred when it was a publicly traded company. Any expenses associated with this public equity may have occurred through quarterly dividend payments to its investors.

Cornell did not need to contribute equity or raise debt, which removes the financial burden on the university. As of December 2018, project costs were estimated at $85 million, which is a $5

million increase from the original cost estimate in February 2017. Of the costs, $34 million is attributed to soft costs while hard costs total $51 million.

According to EdR's annual report in 2017, costs incurred as of December 31, 2017 were $32.1 million. Interest costs were $337,000 in 2017 and $240,000 in 2016, and nearly all other costs were categorized as Buildings and Improvements and Furniture, Fixtures, and Equipment, amounting to $32 million. The bulk of the expenses have been incurred as construction has progressed and delays have compounded.

EdR is liable for annual ground rent payments to Cornell and $2.4 million in property taxes to the Town of Ithaca. A financial and project information summary is provided in **Appendix III**. In terms of pro-forma operations, a 2 BR apartment costs $872 per month with 10- or 12-month options available to students. Assuming a 12-month lease and minimum graduate stipend of $25,152, rent amounts to 41.6% of gross income, which is higher than a standard affordable rate of 30%.

Exit Strategy

EdR pursues both short-term and long-term holds with its properties. Based on the quality and standards for redevelopment of the old Maplewood Park, it is estimated that the property could last at least 25 years before a major overhaul is needed. EdR's 50-year ground lease with Cornell demonstrates a long-term commitment to the project, and Resetco confirmed that "We intended this to be a long term hold."[3]

There is still a possibility that EdR may exit a long-term hold scenario. In June 2018, as part of a $1.2 billion transaction with Blackstone's BREIT, EdR sold a similar apartment in Tucson for a nearly 80% gross return after holding for 6 years.

Exit Strategy Possibility: Similar Property in Arizona	
	<u>Short-Term Hold</u> **Location**: Tucson, AZ **Acquired**: 2012 **Acquisition Price**: $66 million **Sold**: 2018 **Sold Price**: $112 million **Price Per Unit**: $536,780 **Gross Annual Income**: $6 million

[3] Resetco (2018).

With multiple options at its disposal, there are 3 likely possibilities that EdR may pursue.

1. **Long-Term Hold**: Maplewood would be held for the length of the lease. Significant improvements or a new redevelopment may need to occur during that period.
2. **Wait-and-See**: Hold the property for about 25 years, walking away with or without a tenant improvement. This option may be attractive if the return is not promising with little indication of future improvements to the local market.

Short-Term Flip: Hold the property for a relatively short-term, and sell for a considerable capital gain if the market is doing well.

Impact and Innovation of the Development

Impact

The most significant impact of this development is the relief provided for student housing in close proximity to the Cornell campus, utilizing 872 beds, an environmental-friendly utility service, and decent amenities at a fair rent. It is expected to revive a previously rundown area through mixed-use and planning features combining New Urbanism, retail, and more efficient transportation design.

By integrating community programming, public space, and higher densities, the design has brought graduate students closer together. Local input from surrounding neighborhoods was effective in the concept phase, as buildings were moved or redesigned to blend in with the style of Belle Sherman and East Hill. Nevertheless, the consequences of the development have included extended construction timelines, additional financial costs, student displacements, strained labor relations, and polarizing community opinions exemplified by the Does Cornell Care? campaign.

Innovation

The P3 developed with Cornell University has encouraged the sourcing and usage of renewable energy in the design, leading to Energy Star and LEED certifications. In addition, the project derives all energy sources from renewables, and there are no natural gas lines anywhere in the development. Aside from innovations in energy, the new PDZ code was a legislative innovation with the Town Board, allowing for increased density at the site and sparking a conversation for updating outdated zoning codes.

Reference

1. S Kent. Domestic architecture and the use of space: an interdisciplinary cross-cultural study. 1993.
2. S Emmitt. Managing interdisciplinary projects: a primer for architecture, engineering and construction. taylorfrancis.com.
3. N Dunn. Digital fabrication in architecture. 2012.
4. S Feiner, B MacIntyre. A touring machine: Prototyping 3D mobile augmented reality systems for exploring the urban environment. Personal Technologies, 1997.
5. HL Chi, SC Kang, X Wang. Research trends and opportunities of augmented reality applications in architecture, engineering, and construction. Automation in construction, 2013